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EFFECTS OF POLLUTION ON BIOTA OF THE PIGEON RIVER, NORTH CAROLINA AND TENNESSEE

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EFFECTS OF POLLUTION ON BIOTA OF THE PIGEON RIVER, NORTH CAROLINA AND TENNESSEE

CONCLUSIONS

Wastes from the Champion Paper Company and the City of Canton, North Carolina, polluted the Pigeon River and adversely affected the biota of the river in the States of North Carolina and Tennessee. This pollution:

1. Reduced the growth of both the desirable suspended planktonic and bottom attached algae in 20 miles of the Pigeon River and in Waterville Lake, North Carolina, and in the receiving waters of Tennessee.
2. Stimulated the growth of undesirable slime organisms in the reach of river extending from Canton, North Carolina, into the State of Tennessee.
3. Reduced substantially the desirable sensitive fish food organisms from Canton, North Carolina, downstream to Newport, Tennessee, (including Waterville Lake) a total distance of 40 river miles.

4. Increased in numbers the tolerant bottom associated organisms including many disease vector and nuisance insects such as mosquitoes and midges.
5. Destroyed the fisheries in twenty miles of the Pigeon River in North Carolina and caused the waters that entered Tennessee to contain a fish population dominated by large rough-fish such as carp and suckers.

Richland Creek near its confluence with the Pigeon River in North Carolina was found to be polluted. This pollution substantially reduced the number of desirable sensitive organisms that serve as fish food.

Wastes entering the Pigeon River near Newport, Tennessee, polluted the river and adversely affected the biota. Undesirable changes in the biota, especially evident downstream from the Lawrence Tannery, were:

1. A reduction in the quantity of desirable suspended plankton and bottom attached algae and an increase in the quantity of slime organisms.
2. A reduction in the bottom animal fish-food population.
3. A reduction in the fish population with those fishes remaining being predominantly rough-fish such as carp and suckers.

INTRODUCTION

The Pigeon River originates in and flows northwesterly across Haywood County, North Carolina, enters Tennessee near Waterville, North Carolina, and continues northwesterly across Cocke County, Tennessee, to its confluence with the French Broad River near Newport. The watershed is predominantly forested mountains. Agriculture is confined to the foothills in the headwater area around Canton, North Carolina, and the lower portion of the basin near Newport, Tennessee. The mid-reach of the river passes through scenic hills and mountains with a spectacular 13-mile-long gorge located a few miles north of the Smoky Mountain National Park.

The mid-reach of the Pigeon River has been relatively inaccessible. Interstate Highway 40 (construction presently underway, and passable to light traffic) follows the course of the river from Newport, Tennessee, to Canton, North Carolina. This road will be the prime East-West thoroughfare through the southern Appalachian Mountains and will provide for more rapid development of this entire valley. Because of topography, scenery, and future access recreation could become the principal industry of the area.

The total length of the Pigeon River is approximately 70 miles. At river mile* 38, a 180-foot-high dam creates the five-mile-long

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* River miles measured upstream from confluence with French Broad River.

Waterville Lake (Figure 1). Water never passes through and rarely spills over this dam, thus leaving a dry river bed in the natural channel downstream from the dam. This channel remains dry for a short distance; then water flow is gradually renewed by water from tributary mountain streams and seepage. Water from Waterville Lake by-passes the thirteen-mile-long natural channel and is discharged via a seven-mile-long tunnel through the mountains, reentering the natural river channel at a powerhouse located at river mile 25 a few yards upstream from the North Carolina-Tennessee State line.

Several sources of untreated and inadequately treated waste waters enter the Pigeon River. The primary sources of these are: (1) the Champion Paper Company, and municipal sewage at Canton, North Carolina; (2) wastes from the Lawrence Tannery near Newport, Tennessee; and (3) municipal and industrial wastes from the cities of Waynesville, Hazelwood, and Lake Junaluska, North Carolina, that enter the Pigeon River via Richland Creek.

Some of the tributary streams were silted by run-off waters from construction sites along the new interstate highway. Stabilization of cuts and fills through the proper placement of vegetation and/or rock rip-rap is a part of the interstate highway design which will have to be emphasized along Interstate 40 because of the very steep gradient cuts and fills.

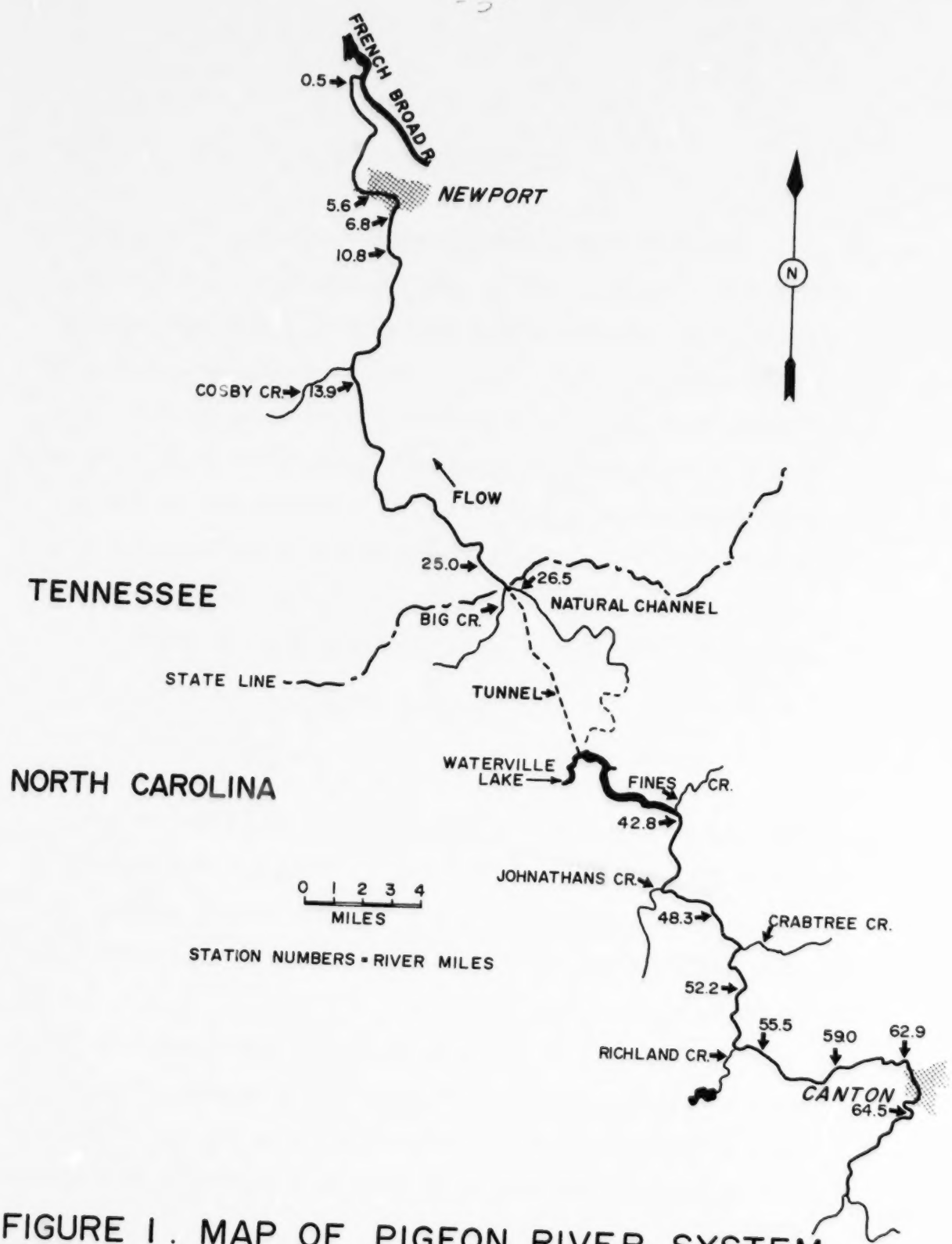


FIGURE 1. MAP OF PIGEON RIVER SYSTEM SHOWING BIOLOGICAL SAMPLING STATIONS.

STREAM INVESTIGATION

Biological field investigations were conducted during the period from July 19 through August 8, 1965. Biological parameters investigated were attached plant and slime growths (periphyton), plankton, bottom animals, and fish. Fourteen stations on the Pigeon River, six stations on tributaries, and a series of stations in Waterville Lake were sampled (Figure 1). Station numbers are designated as river miles measured upstream from the Pigeon River confluence with the French Broad River. Station numbers in Waterville Lake are designated as sections located at one-quarter mile intervals and numbered beginning at the dam (1) and proceeding to the headwaters of the lake (15).

ATTACHED GROWTHS

Glass microscope slides (1 x 3 x 1/16 inch; effective sampling area 5 square inches) were attached to bricks with a nonhardening plastic adhesive and submerged in shallow riffles at each sampling station. After two weeks the slides were recovered for analyses of periphyton (attached algae, protozoa, and slimes) that had accumulated on the slides.

Measurement of the quantity of attached algae present on the glass slides was performed by two methods: (1) scraping and washing the algal cells off the slides, mixing and suspending them in a known quantity of water, and microscopically counting an aliquot of the suspension;

and (2) placing the algal covered slides into a known volume of acetone which serves as a solvent for the extraction of the algae's chlorophyll. The quantity of chlorophyll was determined spectrophotometrically.

Downstream from the City of Canton (river mile 59.0), there was a drastic reduction (96%) in the quantity of attached algal growths (Figure 2). Several components of the wastes from the Champion Paper Company (discharged at river mile 63.0) contributed to this reduction in attached algae. Attached algal growths are important because they are the basic food consumed by aquatic animals. The dark brown color of the paper mill wastes, probably caused by tannins and lignins, reduced the amount of light, or solar energy, that penetrated the water. Energy, as light, is needed by algal chlorophylls to produce food for nourishment, growth, and reproduction of algae. Competition and crowding by slime growths (stalked protozoans, filamentous slime bacteria, and other protozoans) also inhibited, or restricted, the growth of attached algae. Carbon analyses of the growths accumulated on the glass slides revealed substantial increases (up to 180%) in the organic growths downstream from the paper mill (Table 1). Since algae are carbonaceous, they contribute to the total carbon; but, since algae contain chlorophylls and the slimes do not, a community with a high carbon content and low chlorophyll content would be predominantly slime growths. Figure 3 illustrates the carbon to chlorophyll ratios of the periphyton growths in the Pigeon River, and shows that large quantities of slime growths developed a short distance downstream from the paper

FIGURE 2. TWO MEASUREMENTS OF BOTTOM ATTACHED ALGAE, PIGEON RIVER, NORTH CAROLINA & TENNESSEE, JULY-AUGUST, 1965.

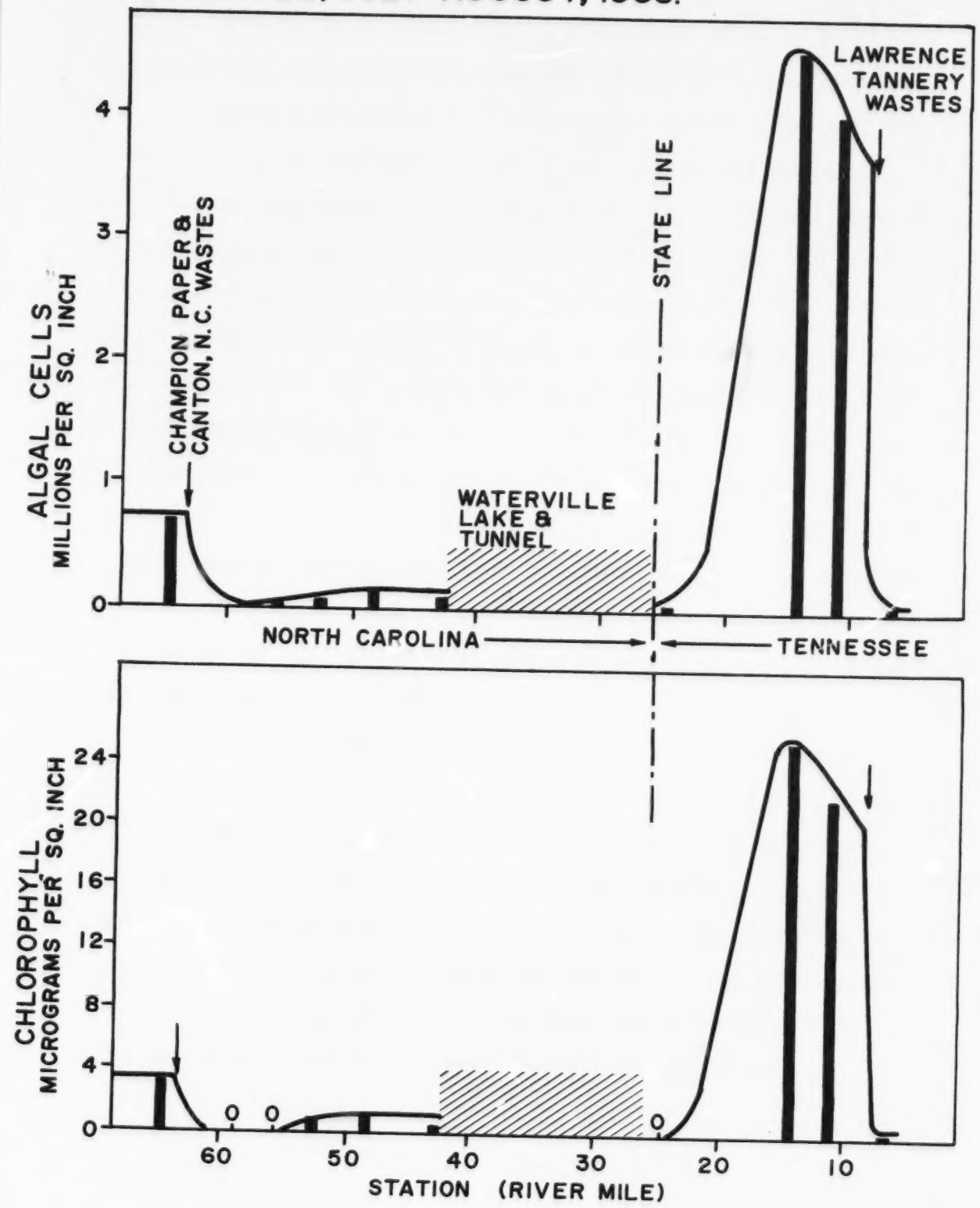
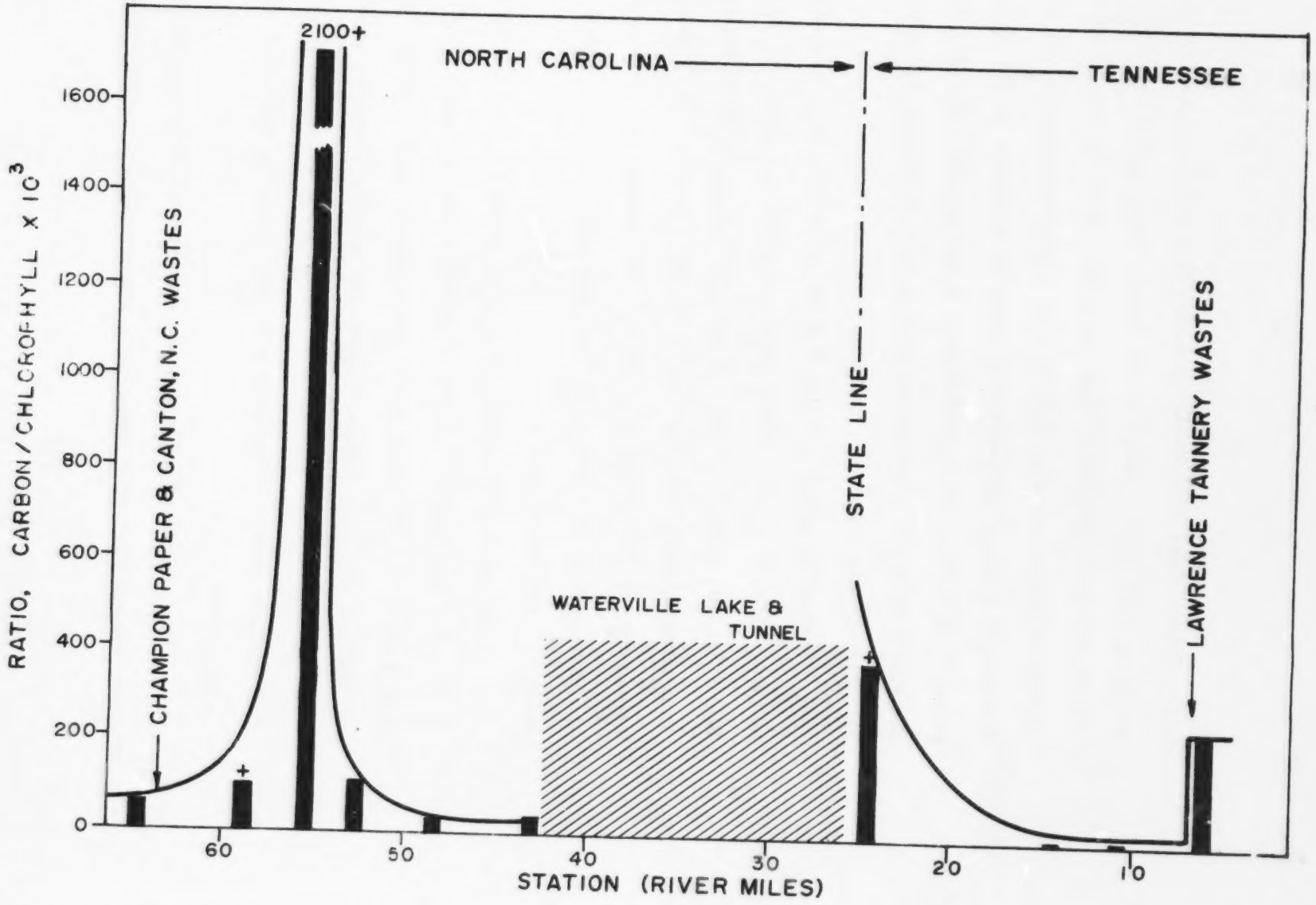


FIGURE 3. RELATIVE DENSITY OF ATTACHED SLIME GROWTHS, PIGEON RIVER, NORTH CAROLINA-TENNESSEE, JULY-AUGUST, 1965.



mill. These slimes undoubtedly resulted from the waste materials, including wood sugars, added to the water. Wood sugars serve as nutrients for the filamentous slime bacteria. Bacteria and microscopic organic particles serve as food for the stalked protozoans and other microscopic animals that were also found in abundance in the severely polluted reaches of the Pigeon River. Slime growths interfere with the growth of algae, propagation of fish food organisms, and the hatching of fish eggs.

Thermal pollution is also a limiting factor for bottom algae and many other forms of aquatic life. Downstream from the Champion Paper Company, water temperatures were substantially increased (maximum temperatures: upstream from mill, Station 64.5, 72°F; downstream from mill, Station 62.9, 87°F). It was possible to stand in the river and to feel radiating heat with one's hand held a few inches above the water's surface.

Anaerobic decomposition of organic materials produces toxic by-products of decomposition, such as methanes and sulfides. Sulfides were present in the Pigeon River, as evidenced by the rotten-egg odor of hydrogen sulfide. Figure 4 shows the sulfide corrosion on silver dimes that were submerged for a two-week period at various stations. The sulfides reacted chemically with the silver to form black silver sulfide.

The effects of pollution on periphytic growths diminished as the river neared Waterville Lake. This was a result of natural reductions

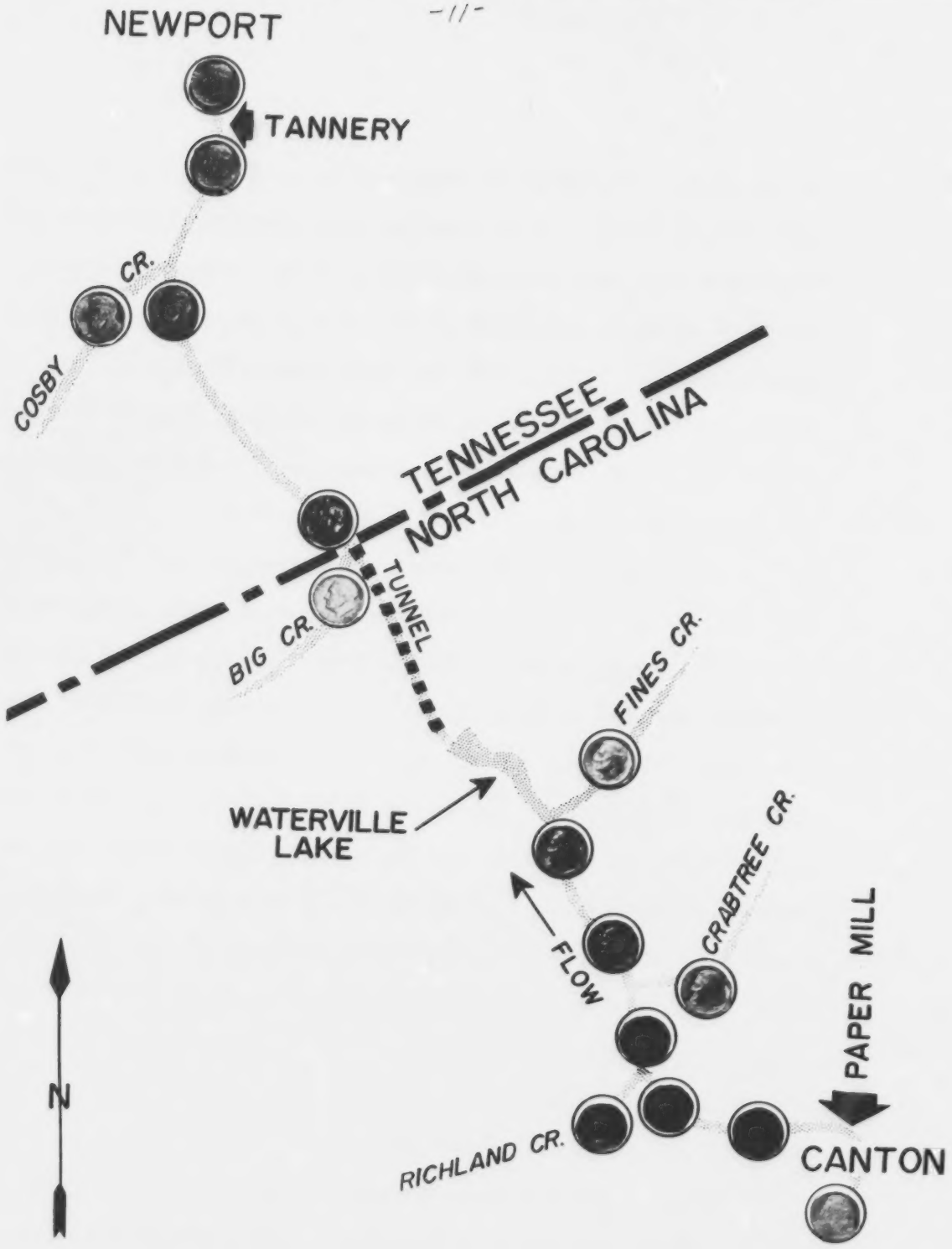


FIGURE 4. CORROSION OF DIMES SUBMERGED FOR TWO WEEKS AT SELECTED SITES IN THE PIGEON RIVER AND TRIBUTARIES.

of the quantity of wastes or changes in the nature of the waste to a less noxious state. In the reach of river immediately upstream from Waterville Lake, dissolved oxygen was present. This was primarily the result of physical reaeration of the river as the water passed through many white-water rapids. Once the water entered Waterville Lake, the reduced aeration could not supply enough oxygen to meet the biochemical oxygen demands of the decomposing organic waste materials remaining in the water. As a result, Waterville Lake was septic.

Septic Waterville Lake water was discharged into Tennessee (river mile 26). Near the point of discharge, attached algal growths were reduced (Figure 2), slime growths increased (Figure 3), and sulfides permeated the area (Figure 4). Within twelve miles downstream from the point of discharge of this water into Tennessee, conditions for the growth of attached algae were essentially reversed - instead of being inhibited, bottom attached algal growths flourished (Figure 2). At Canton, North Carolina, (river mile 63) large quantities of algal nutrients (nitrogen and phosphorus) were discharged in the waste waters. High levels (such as .08-.09 mg phosphorus per liter of water) of nutrients remained in the river downstream in Tennessee. As the water quality improved sufficiently to permit algal growth, the nutrients were used by these microscopic plants.

Tannery wastes entered the river (river mile 7.6) a short distance upstream from Newport, Tennessee. These waste waters adversely affected the bottom attached algae (Figure 2) and stimulated the growth of bottom attached slimes (Figure 3).

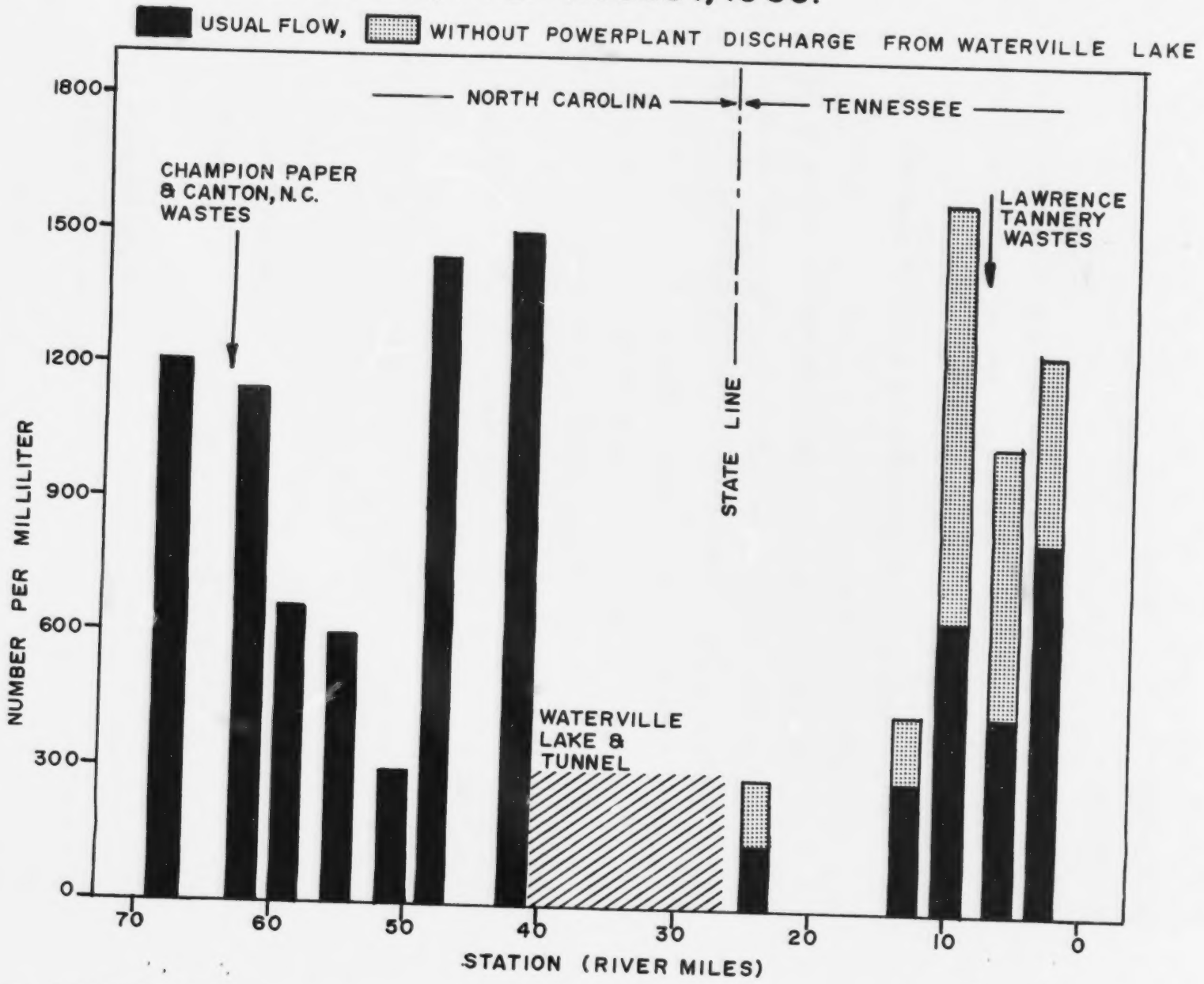
SUSPENDED ALGAE

In the Pigeon River, as in most swift mountain streams, phytoplankton (suspended algae) were sparse. Even so, the effects of pollution on plankton were discernible (Figure 5). Within a short distance downstream from the waste discharges, the numbers of planktonic algae were substantially reduced.

The number of planktonic algal cells began to increase as the river approached Waterville Lake. Plankton in Waterville Lake were ineffective as photosynthetic producers of dissolved oxygen, as evidenced by the absence or near absence of oxygen in the lake's water. The dark color of the lake's water prohibited the penetration of sunlight to all but the uppermost layers of water (secchi disc readings - 18 inches). What oxygen may have been photosynthetically produced in the surface waters was used immediately by the biochemical oxygen demand of the wastes and the respiration of plankton.

Water discharged from Waterville Lake contained very small numbers of planktonic algal cells. During periods of discharge, the downstream reaches of the Pigeon River contained fewer planktonic algal cells per milliliter of water than during periods without discharge of water from Waterville Lake (Figure 5). Thus, these algal-poor lake waters served to dilute the more algal-laden waters from tributaries (such as the natural channel of the Pigeon River and Big and Cosby Creeks) that enter the river in its downstream reaches.

FIGURE 5. PHYTOPLANKTON, PIGEON RIVER, NORTH CAROLINA & TENNESSE, JULY-AUGUST, 1965.



The number of planktonic algal cells gradually increased as the river neared Newport, Tennessee (Figure 5). A short distance upstream from Newport, the addition of tannery wastes (river mile 6.6) inhibited the growth of algae and destroyed a portion of the algae carried into this reach. This effect upon the algae was discernible during both high and low periods of flow (as affected by discharge of water from Waterville Lake). This reduction of algal cells could have been caused by one or more components of tannery wastes; such as toxic chromium, increased suspended solids that reduce light penetration, and organic materials that support the growth of slimes that compete with algae for nutrients. Algae are important because they are the basic food for desirable aquatic animals.

BOTTOM ANIMALS

Large numbers of invertebrate animals live on the bottom of rivers. There are many different kinds, each possessing a different tolerance to pollution. As the quantity and strength of wastes increase, the various kinds of bottom animals are eliminated in the order of their sensitivity to pollution; the most sensitive disappear first, the most tolerant last. Thus, water of poor quality supports only a few kinds of organisms compared to water of high quality, which supports a wide variety of both sensitive and tolerant organisms.

As the more sensitive organisms are eliminated, the vacated space becomes available for use by surviving tolerant kinds. Organic

wastes can be used as food by many of the tolerant kinds; this produces a further increase (proportional to the organic waste utilizable by the tolerant animals). Toxic wastes do not increase the quantity of food; as a result, the total number and kinds of surviving tolerant animals are limited. Excessive quantities of organic wastes, undergoing rapid decomposition, produce large quantities of sulfides, methanes, and other products of decomposition, and reduce the quantity of dissolved oxygen, resulting in an environment that may adversely affect populations of the most tolerant organisms. In summary, the degree of decrease of the number of kinds is related to the type and quantity of wastes; while an increase in the number of surviving tolerant kinds is related to the increase of food as organic wastes added to the water; toxic wastes provide no nourishment for the few surviving tolerant kinds; and excessive quantities of decomposition by-products may produce an environment essentially toxic, thereby limiting the numbers of tolerant forms that would normally utilize these organisms as food.

In addition to serving as a pollution indicator, the community of bottom animals serves as a major link in the aquatic food chain: algae to bottom animals to fish. Some forms of aquatic insects are important as disease vectors, and as nuisances during periods of mass emergence when they get into the eyes, ears, mouths, and nostrils of man, livestock, and wildlife and accumulate as dirt after attraction and death around night-lighted areas.

Immediately downstream from the discharge of wastes at Canton, North Carolina, (river mile 62) the community of bottom animals was decimated (Figures 6 and 7), which is indicative of the severity of pollution. Farther downstream the adverse effects of pollution were reduced sufficiently to permit the existence of large numbers of a few kinds of tolerant organisms, thus indicating the abundant organic food supply.

Waterville Lake possessed a bottom animal community that was also indicative of organic pollution. Near the headwaters of the impoundment (Section 15), the community contained four kinds of midges and sludgeworms, totaling 6,400 organisms per square foot. This sampling site possesses a perceptible current and water of very recent origin from the inflowing river. Bottom animals were not found near the dam (Section 1). Only sludgeworms were found at sampling sites between these two sections (1 and 15). Sludgeworm numbers varied from 40 to 19,500 (mean 7,300) per square foot of bottom.

Downstream from the power-plant discharge into Tennessee, the number of kinds of bottom animals gradually increased and the total number per square foot of bottom gradually decreased (Figures 6 and 7) - a response to the gradual natural purification of organic wastes in the Pigeon River. A short distance upstream from Newport, Tennessee, wastes from the Lawrence Tannery reduced the number of kinds and the total number of bottom animals decreased - a response which indicated the presence of toxic materials.

FIGURE 6. NUMBER OF KINDS OF BOTTOM ANIMALS, PIGEON RIVER, NORTH CAROLINA & TENNESSEE, JULY-AUGUST, 1965.

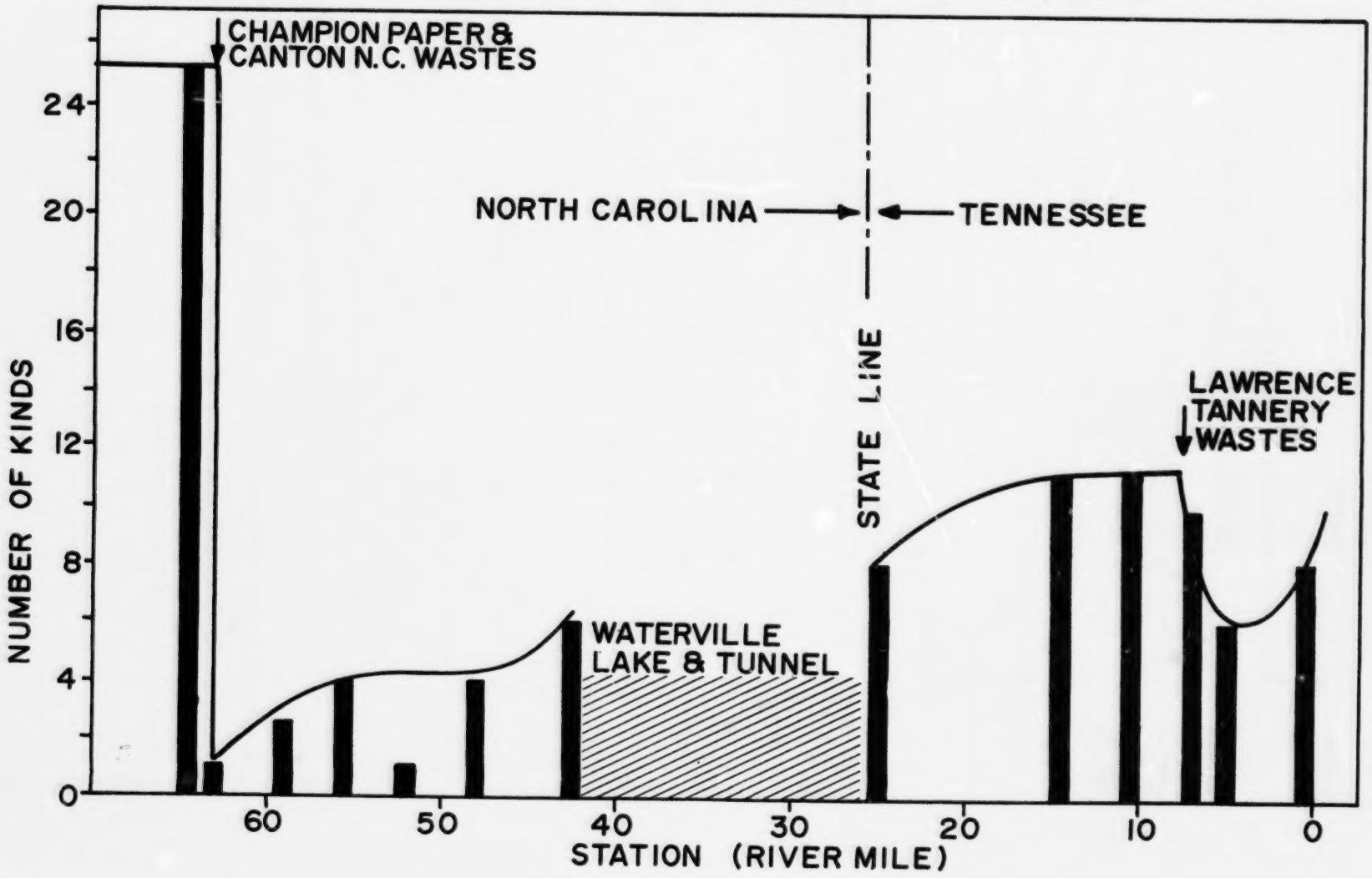
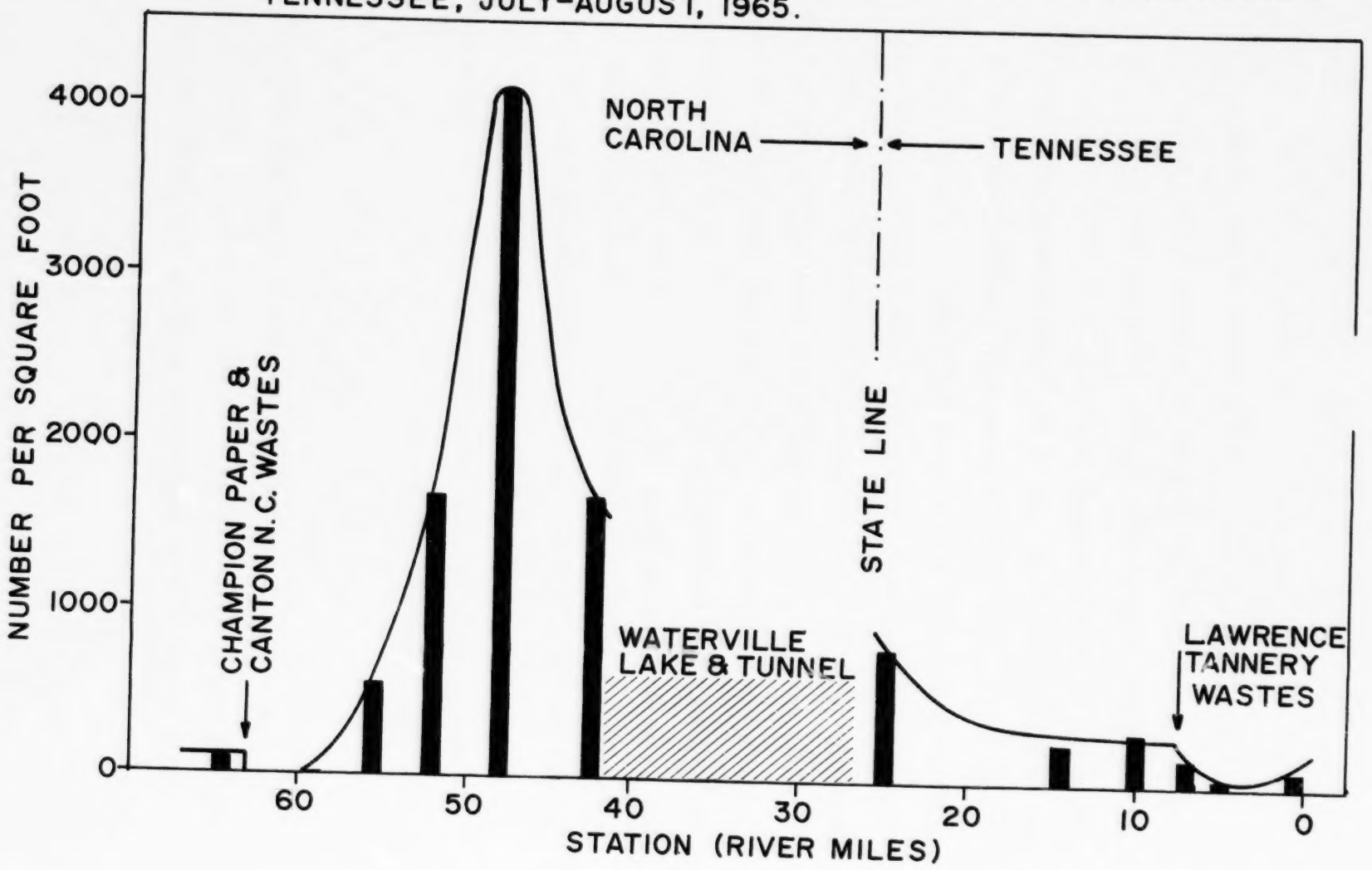


FIGURE 7. NUMBER OF BOTTOM ANIMALS, PIGEON RIVER, NORTH CAROLINA & TENNESSEE, JULY–AUGUST, 1965.

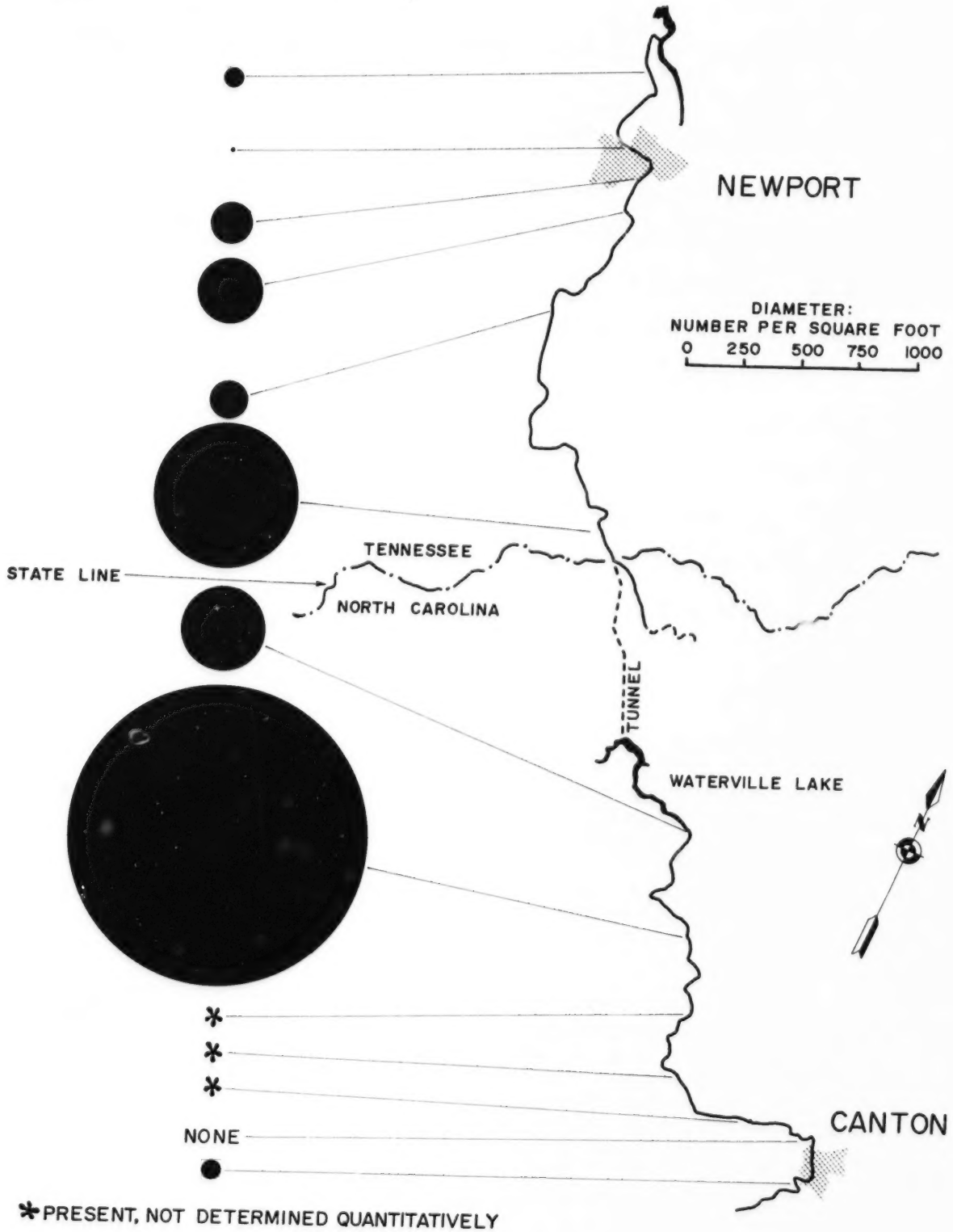


Black flies, mosquitoes, biting midges, midges, sewage flies, bloodworms, and rat-tailed maggots are in water as the immature, or larval, stages of insect life cycles. These are relatively tolerant components of the bottom animal community. Upon their emergence as terrestrial adults, these insects may become serious nuisances and/or disease vectors. Figure 8 illustrates the increase (from 65 up to 1,300 per square foot of bottom) in the number of these organisms, a response to an increased food supply as organic wastes. Immediately downstream (river mile 62 to river mile 55) from the Canton, North Carolina, waste discharges, the numbers of these insects are restricted by the severity of pollution. Here, the sewage mosquitoe is the predominant organism, persisting in the river under overhanging shrubs and along the grassy margins. The sewage mosquito is an important vector of encephalitis. At sampling stations farther downstream, a greater variety of noxious insects in increasing numbers were found. The numbers of noxious insect larvae were substantially increased in the Pigeon River in Tennessee when compared to numbers in samples from neighboring unpolluted waters.

FISH

Fish are the end product of the aquatic food-chain that is utilized by man as food and as a recreational resource. The kinds and quantity of fish present are affected by pollution. Pollutants may directly affect the fish; or, pollution may indirectly affect fish

FIGURE 8 . DISEASE VECTOR AND NUISANCE INSECTS, PIGEON RIVER, NORTH CAROLINA & TENNESSEE, JULY-AUGUST, 1965.



*PRESENT, NOT DETERMINED QUANTITATIVELY

by acting upon other aquatic organisms that nourish, or that compete with fish.

Fish were collected at seven stations with trap-nets (modified fyke). Quantitative data are expressed as the total catch of four nets fished for 1 day (24 hrs) at each sampling station. Two of the sampling stations (64.5, and the natural Pigeon River channel at Waterville, North Carolina) are not affected by pollution.

No fish were captured at the first station (river mile 55.5) downstream from the Canton, North Carolina, waste effluents. Here, pollution was so severe it prevented the existence of fish.1/

An impoverished fish population was observed at Hepco, North Carolina, (Station 42.8). Only a few of two species of fish in low quantity (weight) were collected here.2/

1/ An absence of fish life in this reach of the Pigeon River was also reported by the North Carolina Wildlife Resources Commission: "The section of the Pigeon River in which this sample was taken is so polluted that it supports no fish life."
Messer, James B., 1964. Appendix A, in Appendices to the survey and classification of the Pigeon River and its tributaries. Final Report. Federal Aid in Fish Restoration, Job I-N, Project F-14-R. N. C. Wildlife Resources Commission, Raleigh, N. C.

2/ Data reported by the North Carolina Wildlife Resources Commission supports these findings. In addition, the Commission disregarded the limited value of this depleted fishery because "Fishes from this area are not eaten, however, because of repulsive flavors."
Messer, James B., 1964. (Same as Noted Above)

Waters discharged into the State of Tennessee supported an increased quantity (weight) of fish (Figure 9). Percentage-wise, this population contained more rough-fish, such as carp and suckers, than were present at unpolluted stations (Figure 10). Rough-fish, being more tolerant than sport-fish, are usually predominant in degraded waters.

The tannery waste discharge near Newport, Tennessee, (river mile 6.6) adversely affected the fish. The percentage of rough-fish was higher here when compared to the unpolluted reaches of the river (Figure 10). In addition, the total quantity (weight and numbers, Figures 9 and 10) was reduced.

The number of kinds of fish was substantially reduced by paper mill wastes (Figure 11). This reduction in number of kinds is the result of the pollutants defiling the environment and prohibiting the propagation of the more sensitive and desirable species of sport fish. With time and distance, the natural purification processes gradually improved the water quality and allowed more kinds of fish to be present in the waters.

Near the confluence with the French Broad River (Station 0.5), the quality of water was improved sufficiently to allow an increase in the quantity (weight, Figure 9) of fish with rough-and game-fish present in proportions similar to that found in unpolluted reaches of the river (Figure 10). The number of kinds of fish collected approached the number observed at clean-water stations (Figure 11). Thus, the effects

FIGURE 9. POUNDS OF FISH CAPTURED IN TEST-NETS, PIGEON RIVER, NORTH CAROLINA & TENNESSEE, JULY-AUGUST, 1965

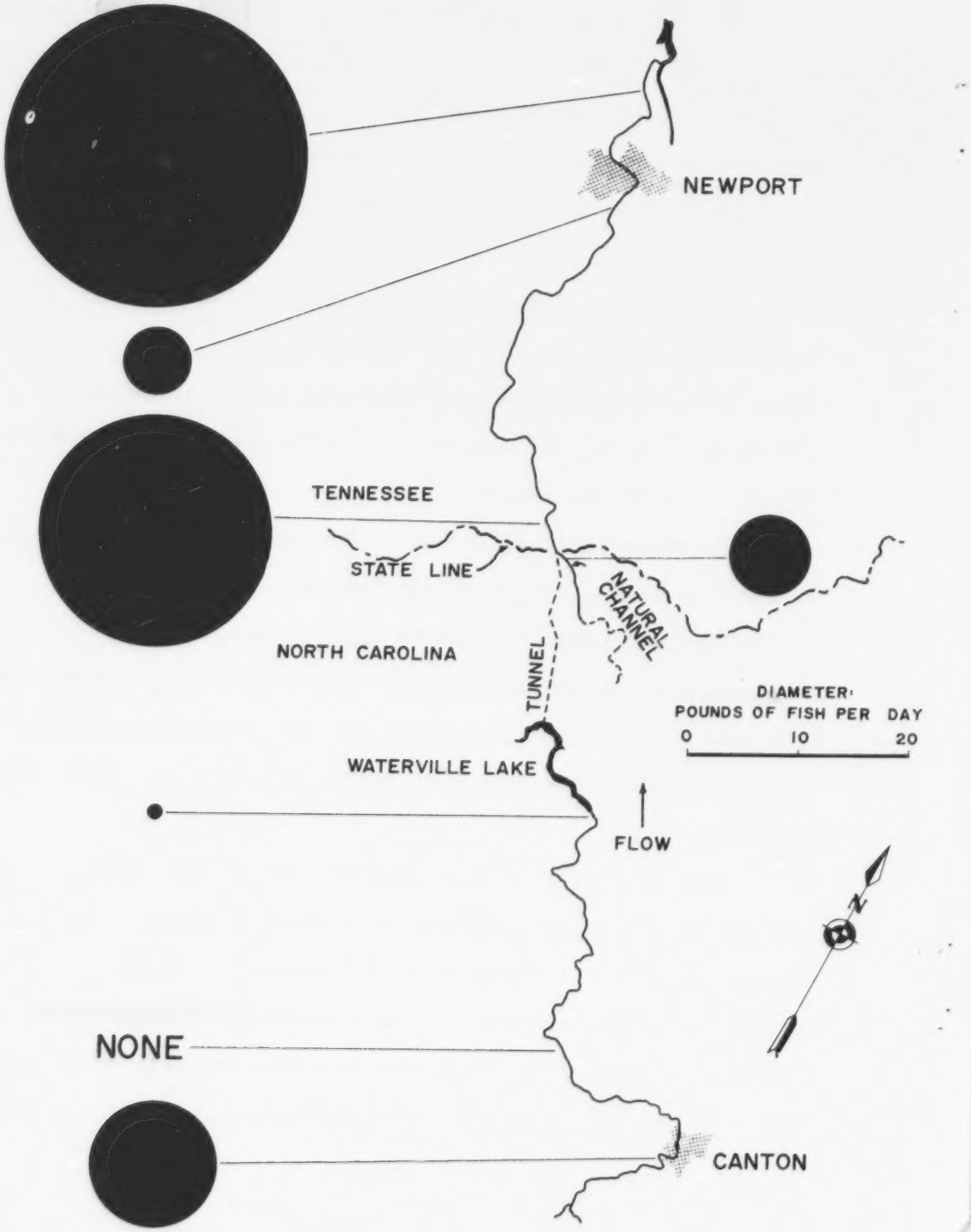


FIGURE 10. FISH CAPTURED IN TEST-NETS, PIGEON RIVER, NORTH CAROLINA & TENNESSE, JULY-AUGUST, 1965

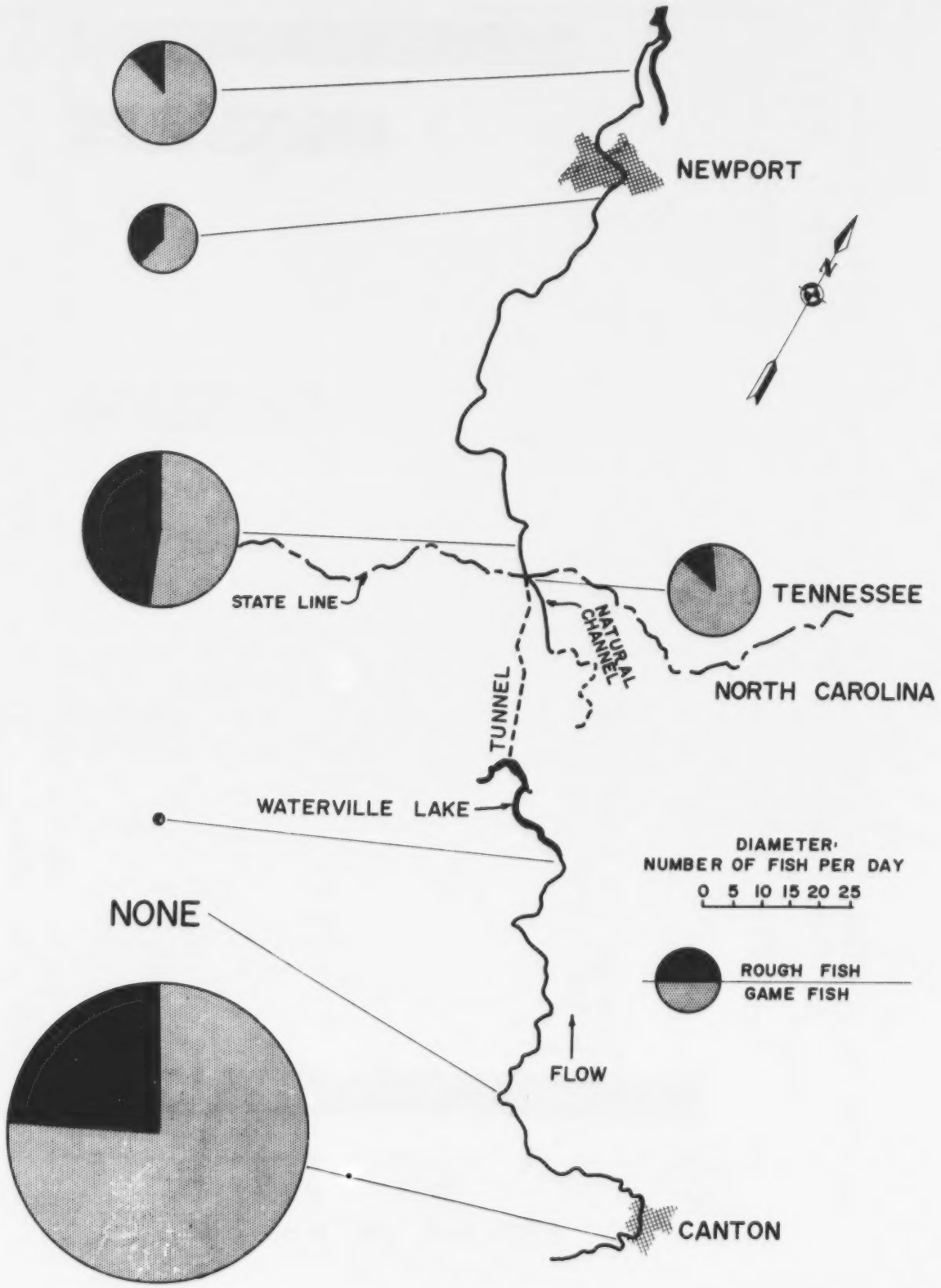
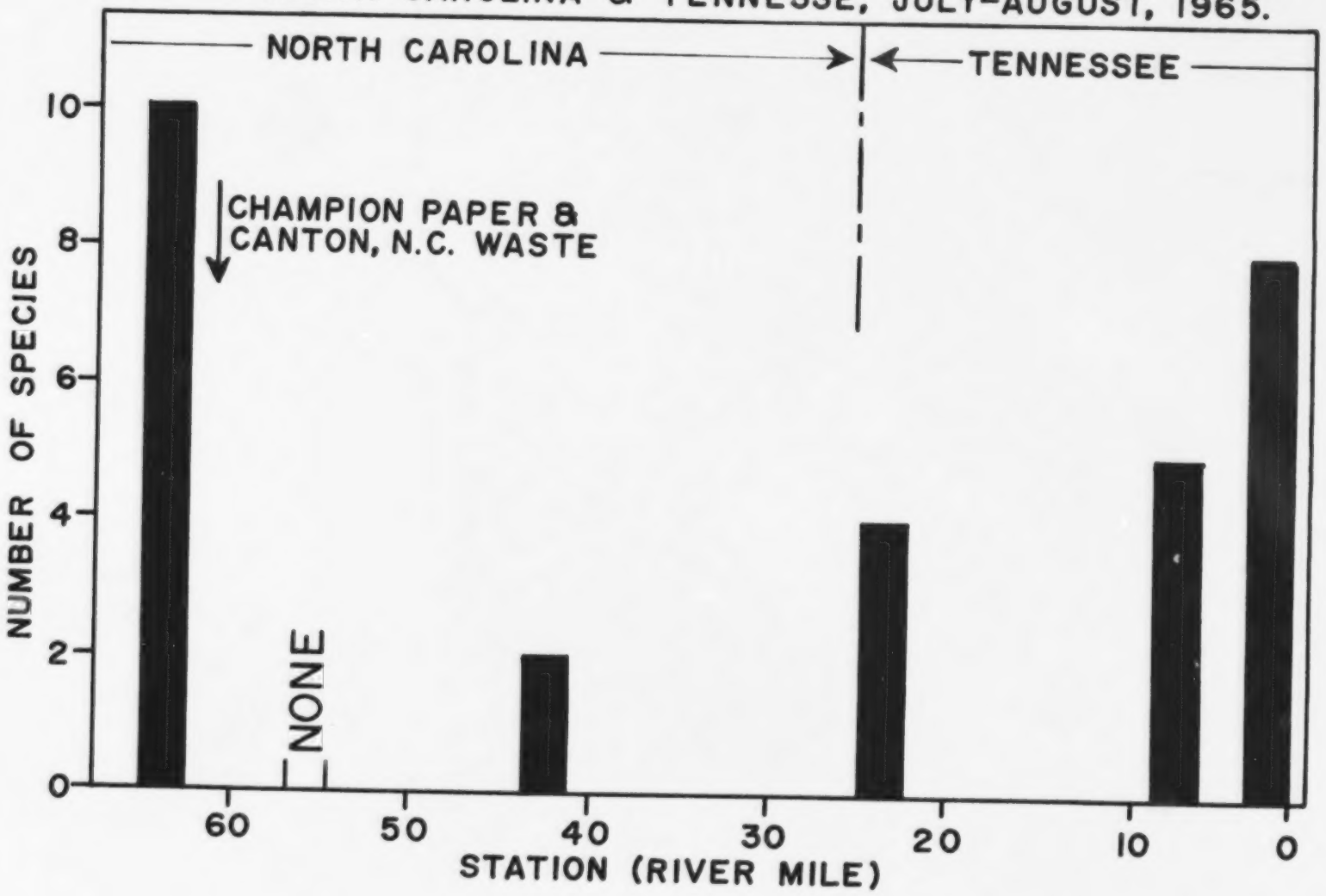


FIGURE 11. NUMBER OF SPECIES OF FISH COLLECTED, PIGEON RIVER, NORTH CAROLINA & TENNESSE, JULY-AUGUST, 1965.



of pollution on fish is mitigated as the Pigeon River waters enter the French Broad River.

TRIBUTARIES OF THE PIGEON RIVER

Sampling was undertaken in six tributaries near their confluence with the Pigeon River. These tributaries were Crabtree Creek, Richland Creek, Fines Creek, Jonathans Creek, Big Creek, and Cosby Creek (Figure 1). Richland Creek was polluted; the remaining five streams possessed an assemblage of biota indicative of clean waters.3/

In July and August, 1965, the number of kinds of bottom animals was reduced, a response indicative of pollution, in Richland Creek when compared to other tributary streams:

	Number of Kinds
Richland Creek	8
Crabtree Creek	20
Fines Creek	21
Jonathans Creek	20
Big Creek	14
Cosby Creek	19

3/ Richland Creek was also found to be polluted in a survey by the North Carolina Wildlife Resources Commission: "The stream is severely polluted by both industries and municipalities. The sample station was located directly below Lake Junaluska Dam. Fishing in this stretch is mostly for suckers and carp.... The heavy pollution apparently has a rather profound effect on the bottom fauna."
Messer, James B., 1964. Appendix A, in Appendices to the survey and classification of the Pigeon River and its tributaries. Final Report. Federal Aid in Fish Restoration, Job I-N, Project F-14-R. N. C. Wildlife Resources Commission, Raleigh, N. C.

In Richland Creek, compared to the other tributaries, sensitive bottom animals were less prevalent in the community and intermediate forms (principally midges and black flies) were strongly predominant, a community indicative of moderate to intense pollution:

	Bottom Animals (percent)	
	Sensitive	Intermediate
Richland Creek	18	79
Crabtree Creek	77	22
Jonathans Creek	43	57
Fines Creek	53	47
Big Creek	72	28
Cosby Creek	46	54

Glass-slide samples of periphyton from Richland Creek contained more algae (as chlorophyll) than was found in other tributary streams.

	Chlorophyll Micrograms Per Square Inch
Richland Creek	18.6
Crabtree Creek	10.0
Fines Creek	5.3
Big Creek	5.6
Cosby Creek	11.2

This larger quantity (and growth rate) of algae in Richland Creek is probably the result of increased algal nutrients in waste waters discharged to the stream.

BIOLOGICAL POTENTIAL

"Due to the scenic nature of the area, the greatest potential future development will probably be in the realm of tourist and recreational activities. The recreational resources of the area should be

diligently safeguarded."[4/] The potential recreational use is further magnified by the construction of Interstate Highway 40. This highway will provide access to the entire scenic Pigeon River Valley, located along the northern boundary of Great Smoky Mountains National Park. The Pigeon River's prime contribution to the recreational potential lies in its scenic value, boating, and fishing resources. Hunting and other forms of recreation are less dependent upon the river, but are also influenced.

The present scenic value of the river is limited. The dark brown to inky black water does not appear detrimental from a distance. But, upon closer examination, such as would occur at water-side picnic or camping grounds, the polluted waters would be objectionable. Odors, slimes, and foam seriously detract from the rivers scenic value.

If clean, the swift flowing Pigeon River could attract white-water canoeists, kayakists, and float-trip enthusiasts. A clean Waterville Lake would also be attractive for boating and water skiing.

With clean water, the Pigeon River would have a spectacular sports fishery potential. The Waterville Dam (180 feet high with no overflow and no provisions for fish passage) and the underground power tunnel prohibit the migration of fish between the upper and lower

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4/ State Stream Sanitation Commission. 1957. The French Broad River Basin. Pollution Survey Report No. 5. North Carolina State Board of Health, Raleigh, N. C. 231 pp.

reaches of the river. Thus, there would be two separate areas for development of a fishery - the upper reach in North Carolina and the lower reach in Tennessee.

The upper reach (North Carolina) could support an excellent smallmouth bass fishery, possibly supplemented with a limited brown trout population. Waterville Lake would produce a warm water fishery in the upper warm waters and a cold water fishery for trout in the deeper cold waters. During fall, winter, and spring, trout would migrate from Waterville Lake upstream into the Pigeon River and its tributaries. In many States, such a "winter" trout fishery is being heavily used as a sport fishery where special regulations permit.

The lower reach (Tennessee) could support a good smallmouth bass population. If temperatures and volume of water permitted, a trout fishery could be established in a short reach immediately downstream from the powerhouse at Waterville, North Carolina. Near Newport, Tennessee, channel catfish could be included in a sport fisheries development program. Seasonally, fish (such as sauger and drum) would migrate upstream from Douglas Lake and contribute to the sport fisheries of the lower Pigeon River.

TABLE 1

Summary of Analysis of Periphyton from Glass-slides
Pigeon River
North Carolina and Tennessee
July-August, 1965

Station (River Mile)	Chlorophyll A. ug/sq. inch	Carbon mg/sq. inch	Diatoms per sq. inch	Miscellaneous algae per sq. inch	Slime Bacteria (Sphaerotilus) units* per sq. inch	Stalked Protozoans (Vorticellidae) per sq. inch	Miscellaneous Protozoa	Rotifers per sq. inch
64.5	3.2	92	630,000	2,500	0	0	100	0
59.0	< 0.1	12	5,000	0	0	10,000	875,000	0
55.5	< 0.1	258	5,000	0	0	120,000	400,000	0
52.2	0.9	106	25,000	0	0	925,000	175,000	100
48.3	1.2	35	20,000	10,000	330,000	313,200	82,000	12,920
42.8	0.3	12	25,000	10,000	35,000	5,000	600,000	0
25.0	< 0.1	48	10,000	0	25,000	5,800	220,000	968
13.9	26.5	4	8,580,000	420,000	0	0	60,000	0
10.8	21.8	25	7,680,000	700,000	0	0	40,000	0
6.8	0.1	30	7,200	800	0	3,200	120,000	400
Tributaries:								
Richland Creek	18.6	5	2,940,000	460,000	0	4,000	80,000	0
Crabtree Creek	10.0	21	NO SAMPLE - - -

Table 2

Summary of Phytoplankton Data
Pigeon River, North Carolina and Tennessee
July-August, 1965

(Number per Milliliter of Water)

Station (River Mile)	Diatoms Centric	Diatoms Pennate	Green Algae	Yellow-green Algae	Blue-green Algae	Flagellates	Total
64.5	50	350	800	-	-	-	1,200
62.9	-	-	850	-	-	300	1,150
59.0	-	-	350	-	-	300	650
55.5	-	50	500	-	-	50	600
52.2	50	50	200	-	-	-	300
48.3	50	50	1,250	50	50	-	1,450
42.8	100	250	950	-	200	-	1,500
25.0							
High Water*	-	-	100	-	50	-	150
Low Water**	-	50	100	-	150	-	300
13.9							
High Water	-	200	100	-	-	-	300
Low Water	-	200	150	-	100	-	450
10.8							
High Water	50	150	450	-	-	-	650
Low Water	-	150	1,550	-	-	-	1,700
6.8							
High Water	-	150	300	-	-	-	450
Low Water	-	200	650	-	-	200	1,050
5.6							
High Water	50	350	250	-	100	100	850
Low Water	100	250	650	-	200	50	1,250
			TRIBUTARIES				
Richland Creek	50	250	550	500	100	50	1,500
Crabtree Creek	-	1,400	100	-	-	-	1,500
Johnathons Creek	-	800	100	-	-	-	900
Fines Creek	-	650	50	-	-	-	700
Big Creek	-	200	-	-	-	-	200
Cosby Creek	-	300	50	-	-	-	350

* High Water = Water from Waterville Lake being discharged through powerhouse at Waterville, N. C.

** Low Water = No water discharge from Waterville Lake.

TABLE 3

Bottom Animals, Pigeon River

North Carolina and Tennessee

July-August, 1965

(Number per square foot)

Station (River Mile) ——>	64.5	62.9	59.0	55.5	52.2	48.3	42.8	25.0	13.9	10.8	6.8	5.6	0.5
Sensitive Organisms													
Stoneflies													
Pteronarcys	Q	-	-	-	-	-	-	-	-	-	-	-	-
Acroneuria	Q	-	-	-	-	-	-	-	-	-	-	-	-
Paragnetina	Q	-	-	-	-	-	-	-	-	-	-	-	-
Mayflies													
Stenonema	16	-	-	-	-	-	-	-	2	10	-	-	6
Baetis	43	-	-	-	-	-	-	-	-	-	-	-	-
Ephemerella	1	-	-	-	-	-	-	-	-	-	-	-	-
Caenis	6	-	-	-	-	-	-	-	-	-	-	-	-
Potamanthus	2	-	-	-	-	-	-	-	-	-	-	-	-
Heptagenia	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	Q	-	-	-	-	-	-	-	2	2	-	-	2
Isonychia	Q	-	-	-	-	-	-	-	-	-	-	-	-
Caddisflies													
Cheumatopsyche	4	-	-	-	-	-	-	-	6	6	Q	2	-
Hydropsyche	4	-	-	-	-	-	-	-	13	16	-	2	2
Polycentropus	Q	-	-	-	-	-	-	-	-	11	-	-	-
Psychomyia	5	-	-	-	-	-	-	-	-	-	-	-	-
Hellgrammites													
Corydalus	Q	-	-	-	-	-	-	-	-	-	-	3	-
Fishflies													
Chauliodes	-	-	-	-	-	-	-	-	2	-	-	-	-
Riffle Beetles													
Optioservus	8	-	-	-	-	-	-	-	-	-	-	-	-
Ordobrevia	5	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal	101	0	0	0	0	0	0	0	25	39	1	7	10
Subtotal Kinds	17	0	0	0	0	0	0	0	5	5	1	3	3
Intermediate Organisms													
Black Flies													
Prosimuluim	-	-	-	-	-	-	-	208	-	-	-	-	-
Simulium	8	-	-	-	-	-	-	122	-	-	-	-	-
Midges													
Cardiocladius	Q	-	-	-	-	-	-	-	51	145	48	-	-
Polypedilum	-	-	-	-	-	112	-	160	32	32	32	-	-
Pentaneura	-	-	-	-	-	-	-	16	70	51	32	5	10
Tendipes	9	-	-	-	-	-	1	48	-	32	-	-	-
Spaniotoma	6	-	-	-	-	-	-	20	35	-	16	-	5
Cricotopus		-	-	-	-	-	-	-	-	-	16	8	11
Calopsectra		-	-	-	-	16	24	-	-	-	-	-	-
Microtendipes		-	-	-	-	-	-	-	-	-	-	-	-
Tricholadius	-	-	-	-	-	-	-	-	-	-	-	-	10
Psectrocladius	-	-	-	-	-	-	9	-	-	-	-	-	-
Snipe Flies													
Atherix	Q	-	-	-	-	-	-	-	-	-	-	-	-
Crane Flies													
Antocha	3	-	-	-	-	-	-	-	2	8	6	-	-
Sowbugs													
Asellus	-	-	-	-	-	-	-	29	-	3	-	-	-
Biting Midges													
Bezzia	2	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal	69	0	0	0	0	128	34	603	190	271	150	13	36
Subtotal Kinds	8	0	0	0	0	2	3	7	5	6	6	2	4
Tolerant Organisms													
Shore Flies													
Brachydentera	-	Q	Q	-	-	-	-	-	-	-	-	-	-
Snails													
Physa	-	-	-	-	-	-	272	-	-	-	2	-	-
Bloodworms													
Tendipes	-	-	-	-	-	1190	321	-	-	-	-	-	-
Sludgeworms													
Tubificidae	-	-	3	541	1683	2765	1033	179	2	-	5	8	40
Sewage Flies													
Psychoda	-	-	Q	-	-	-	-	-	-	-	-	-	-
Sewage Mosquitoes													
Culex	-	-	Q	Q	-	-	-	-	-	-	-	-	-
Rat-tailed Maggots													
Tubifera	-	-	-	Q	-	-	-	-	-	-	-	-	-
Subtotal	0	1	5	544	1683	3955	1626	179	2	0	7	8	40
Subtotal Kinds	0	1	3	4	1	2	3	1	1	0	2	1	1
Grand Total	170	1	5	544	1683	4083	1660	782	217	310	158	36	86
Number of Kinds	25	1	3	4	1	4	6	8	11	11	10	6	8

Q = Organisms not collected quantitatively, arbitrarily given value of one for computing

TABLE 4

Bottom Animals, Pigeon River
Tributaries, North Carolina and Tennessee
July-August, 1965. (Number Per Square Foot)

	Richland Creek	Crabtree Creek	Johnathons Creek	Pines Creek	Big Creek	Cosby Creek
SENSITIVE ORGANISMS						
STONEFLIES						
Pteronarcys	-	-	-	-	-	-
Isoperla	-	Q	Q	Q	-	-
Leuctra	-	-	-	-	-	-
Perlesta	-	-	Q	-	-	-
Acroneuria	-	-	Q	-	5	-
Paragnetina	-	-	-	-	2	-
Brachyptera	-	2	-	-	5	-
Peltoperla	-	-	-	Q	-	6
						2
MAYFLIES						
Stenonema	-	29	8	6	3	24
Baetis	-	22	29	24	3	-
Caenis	-	-	-	-	-	3
Potamanthus	-	-	-	-	-	6
Iron	-	6	3	-	5	-
Pseudocloeon	-	5	8	Q	6	-
Isonychia	-	-	-	-		-
CADDISFLIES						
Cheumatopsyche	19	3	22	5	6	11
Hydropsyche	5	6	62	5	6	5
Psychomyia	-	-	-	-	5	-
HELLGRAMMITES						
Corydalus	-	3	-	Q	-	3
FISHFLIES						
Chauliodes	-	-	Q	-	-	-
WATER PENNIES						
Psephenus	-	Q	Q	-	-	2
NET-WINGED MIDGES						
Blepharicera	-	-	16	Q	-	10
RIFFLE BEETLES						
Optioservus	-	-	-	-	-	2
SUBTOTAL	24	77	154	47	46	74
SUBTOTAL KINDS	2	10	13	11	10	11
INTERMEDIATE ORGANISMS						
BLACK FLIES						
Prosimulium	19	-	-	-	3	-
Simulium	5	2	2	2	-	3
MIDGES						
Cardiocladius	-	Q	66	Q	-	-
Polypedilum	Q	5	30	8	-	27
Pentaneura	-	2	-	-	-	18
Spaniotoma	64	Q	16	Q	2	-
Cricotopus	18	2	80	16	-	-
Calopsectra	-	-	-	8	-	-
Microtendipes	-	-	-	-	-	32
Brillia	-	-	-	Q	-	-
Harnischia	-	2	-	-	-	-
Pseudochironomus	-	-	Q	-	-	5
SNIPE FLIES						
Atherix	-	-	-	Q	-	
CRANE FLIES						
Antocha	-	3	11	2	11	2
Protoplasa	-	-	-	-	-	Q
SNAILS						
Stagnicola	-	4	-	Q	2	-
SUBTOTAL	107	22	206	41	18	88
SUBTOTAL KINDS	5	9	7	10	4	7
TOLERANT ORGANISMS						
SLUDGEWORMS						
Tubificidae	5	2	-	-	-	Q
SUBTOTAL	5	2	0	0	0	1
SUBTOTAL KINDS	1	1	0	0	0	1
GRAND TOTAL	136	101	360	88	64	163
NUMBER OF KINDS	8	20	20	21	14	19

Q = Organisms not collected quantitatively, arbitrarily given value of one for computing.

TABLE 5

Summary of Fish Captured in Test-Nets
Pigeon River, North Carolina-Tennessee
July-August, 1965
(Weight in Pounds)

	Station (River Miles)													
	64.5		55.5		42.8		25.0		26.5[1]		6.8		0.5	
Days Fished [2]	1.33		1.00		2.00		1.00		1.00		2.00		2.25	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight
SPECIES						GAME FISH								
Smallmouth Bass	11	0.39	-	-	-	-	-	-	-	-	-	-	-	-
Largemouth Bass	-	-	-	-	-	-	1	0.85	-	-	-	-	6	2.83
Redbreast Sunfish	6	0.66	-	-	-	-	1	0.14	-	-	7	2.4	-	-
Bluegill	7	0.20	-	-	2	0.30	11	2.57	13	3.09	3	0.10	4	0.08
Rockbass	27	2.16	-	-	-	-	-	-	-	-	-	-	-	-
Sauger	-	-	-	-	-	-	-	-	-	-	2	0.10	4	0.71
White Catfish	-	-	-	-	-	-	-	-	-	-	-	-	4	4.24
Channel Catfish	-	-	-	-	-	-	-	-	-	-	1	0.04	13	6.39
Flathead Catfish	-	-	-	-	-	-	-	-	-	-	-	-	2	5.19
						ROUGH AND FORAGE FISH								
Tuckasegee Darter	1	0.06	-	-	-	-	-	-	-	-	-	-	-	-
Banded Sculpins	1	0.02	-	-	-	-	-	-	-	-	-	-	-	-
Horny Head & River Chubs [3]	6	0.48	-	-	-	-	-	-	-	-	-	-	-	-
Common White Suckers	3	2.70	-	-	1	0.63	11	5.82	1	0.42	-	-	-	-
Northern Hog Suckers	5	0.82	-	-	-	-	-	-	-	-	-	-	-	-
Carp	-	-	-	-	-	-	-	-	-	-	8	4.54	2	0.57
Alligator Gar	-	-	-	-	-	-	-	-	-	-	-	-	2	10.57
Total	67	7.42	0	0	3	0.93	24	9.38	14	3.51	21	5.02	37	30.58
Per Day Fished	50	5.58	0	0	2.0	0.47	24	9.38	14	3.51	11	2.51	16	13.59
Number of Species	10		0		2		4		2		5		8	

[1] Pigeon River (old channel) upstream from powerhouse at Waterville, N. C.

[2] 4 nets fished per day.

[3] Two species.